Design Models for Development of Helium-Carbon Sorption Coolers

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This research was carried out by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

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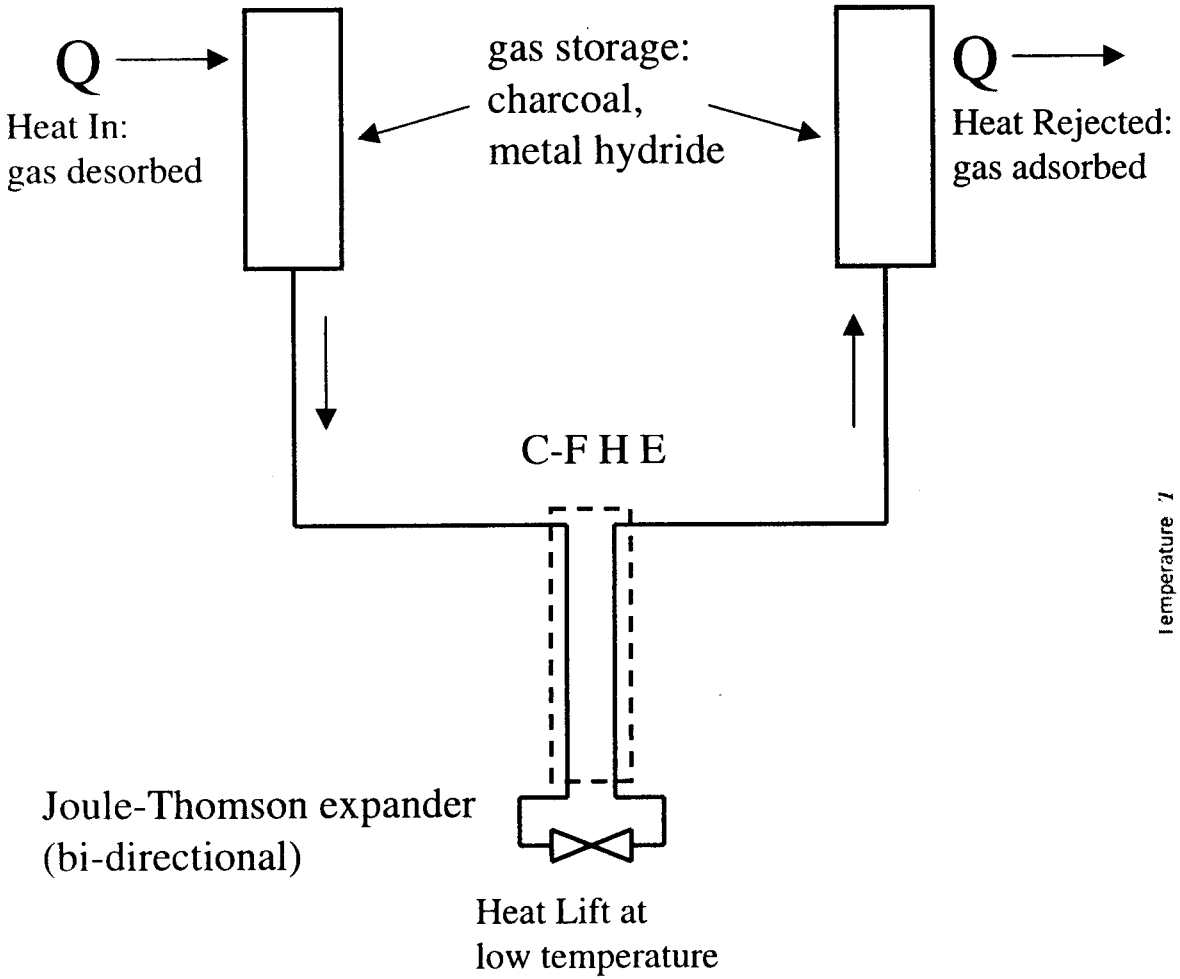
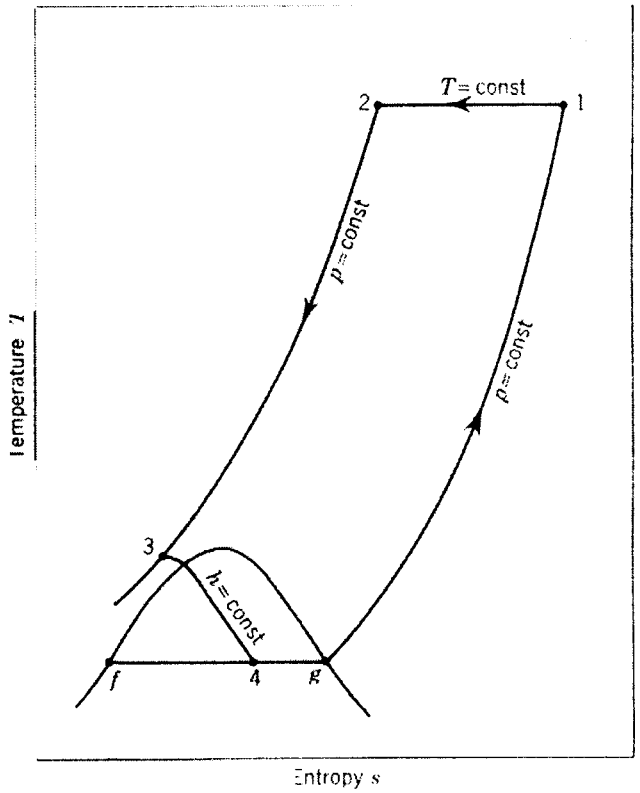
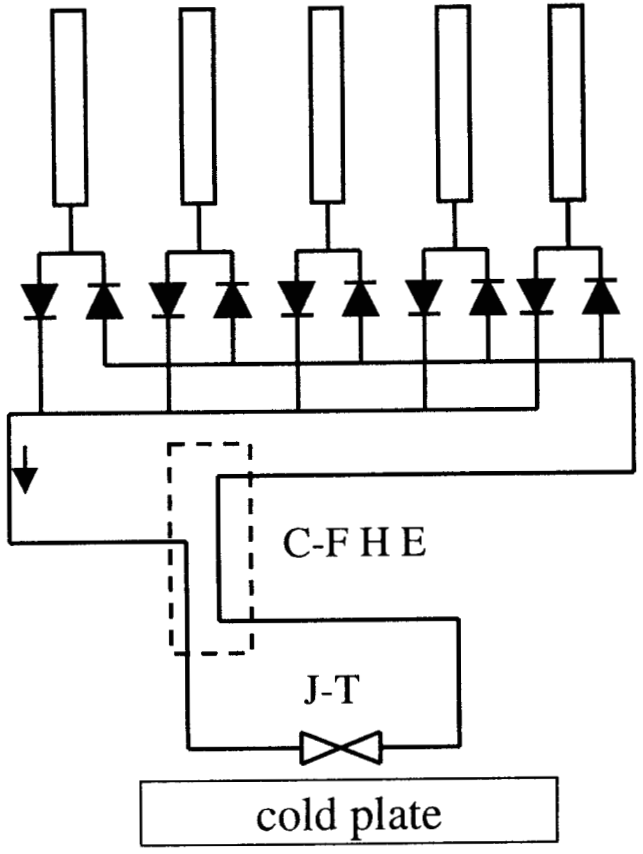
Designs for continuous cooling to 4--6 K



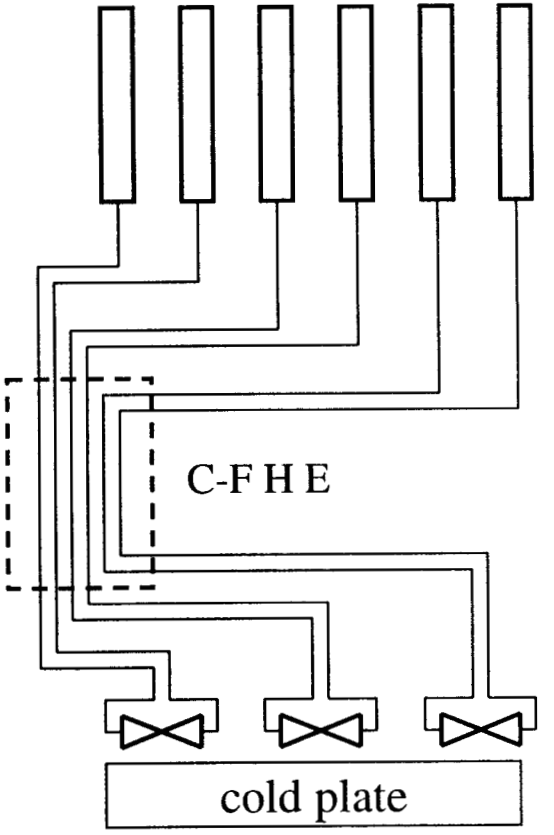


Implementation of continuous cooling

Single J-T with check-valves



Multiple bi-directional J-Ts



Helium-Carbon cooler design model

model inputs

No. of compressor elements
cycle time
precooling temperature(s)
maximum compressor temperature
desorption and adsorption pressures
required cold plate temperature
required power lift
heat exchanger efficiency
materials properties of charcoal and container
allowable pressure drops in tubing
safety margins in pressure and temperature
heater electrical properties
length of J-T constriction

model outputs

charcoal mass required
optimized dimensions of compressor elements
container mass
required heat rejection at precooler
efficiency of system
total mass of compressor elements
required C-F mechanical configuration
diameter of J-T constriction
heat switch parameters (for Helium gas-gap)

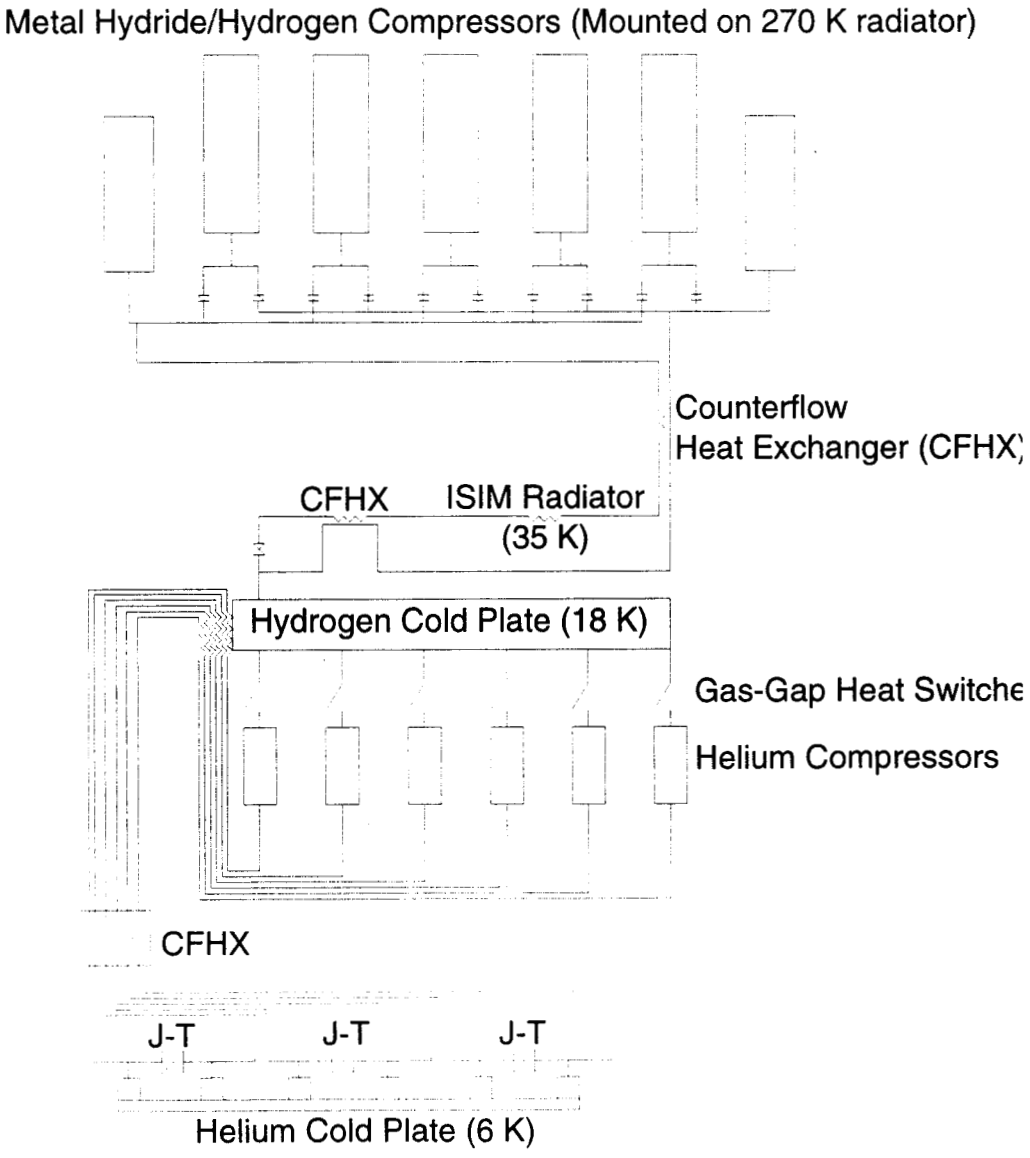
Basis of design model:

employs GasPak code from NIST, coupled to Excel spreadsheet to find enthalpy of Helium gas

charcoal properties from Duband, fits to Dubinin sorption model

either set of properties can be replaced by data in tabular or functional form

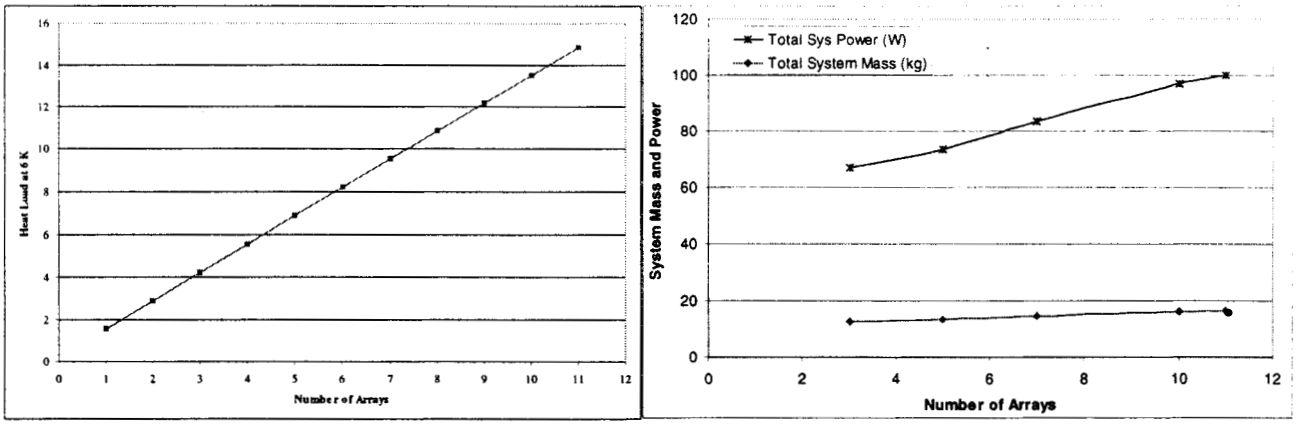
Proposed Design for NGST 2-stage sorption cooler



Model predictions for NGST 2-stage system performance

He-Carbon performance from design models

H2--metal hydride performance from similar models and scaling of Planck coolers



A) The heat lift required at 6 K as a function of the number of detector arrays.
B) the total system mass and power as a function of the number of detector arrays.

Table 2. Cooler System Properties for Various 6 K Cooling Loads

Heat Lift At 6 K (W)	Charcoal Input Power (W) (at 18 K)	Charcoal Sys Mass (kg)	Hydride Input power (W) (at 270 K)	Hydride System Mass (kg)	Total System Power (W)	Total System Mass (kg)	Passive Cooling requirements (W)	
							At 35 K	At 270 K
0.005	0.43	.56	66.4	12	66.8	12.6	0.44	66.4
0.007	0.58	.71	72.9	12.7	73.5	13.4	0.59	72.9
0.010	0.81	.95	82.6	13.7	83.4	14.6	0.82	82.6
0.014	1.12	1.27	95.6	15.1	96.7	16.4	1.13	95.6
0.015	1.20	1.34	98.9	15.4	100.1	16.7	1.21	98.9